6.0 POLLUTION SOURCE INVENTORY AND WATER QUALITY ANALYSIS

The objective of this chapter is to identify areas with potential water quality problems. To satisfy this objective, several types of information were compiled. First, the domestic and industrial point sources within the study area were identified. Second, a map of stormwater outfalls was examined. Third, water quality data were obtained and reviewed in order to document the differences among basins and within basins in the Estero Bay Watershed. Fourth, areas set aside for protection or restoration are identified and reviewed. Lastly, a compilation was made of potential management practices that may be available to resource managers to alleviate water quantity and quality problems in the watershed.

More detailed indicators of water quality (e.g., pollutant loads) are being compiled in a separate Basin Prioritization report. The results from the basin prioritization will identify the specific subbasins where specific management strategies could be used to address the problems identified.

6.1 Point Source Inventory

The Estero Bay Watershed contains 101 domestic point sources permitted by the Florida Department of Environmental Protection (FDEP) for discharge to waterbodies or lands within the watershed area. A summary of the domestic point sources in the watershed is presented in Table 6-1. Plate 6-1 presents the locations of the these point sources. The map ID's in Table 6-1 corresponds to the map ID's in Plate 6-1.

The Imperial River Basin contains most of these sources, totaling 31 domestic sources. Other basins with relatively large numbers of domestic sources include the Estero River (13), Six-Mile Cypress Slough (12), and Cow Creek (10). The Corkscrew Swamp and Lake Trafford basins contain the fewest domestic point sources.

Table 6-1. Domestic point sources in the Estero Bay Watershed.

MAP ID	FACILITY ID	SECONDARY BASIN	TERTIARY BASIN	NAME	TREATMENT
D4	FLA014489	8	1	Anglers Paradise Trailer Park	Extended Aeration to Sand Filter
D5	FLA014679	8	3	Bamboo Mobile Village	Extended Aeration to Retention Pond
D6	FLA014445	11	1	Bay Harbor Club	Extended Aeration
D7	FLA014601	4	1	Beach and Tennis Club	Contact Stabilization to Drainfield
D9	FLA014659	11	1	Bonita Beach Club Condo.	Extended Aeration w/ Sand Filter
D10	FLA014609	8	1	Bonita Beach Trailer Park	Extended Aeration to Perc Pond
D12	FLA014624	8	1	Bonita Fairways STP	Extended Aeration
D13	FLA014590	8	2	Bonita Lake Resort	Extended Aeration to Retention Pond
D14	FLA014448	7	3	Bonita Lanes	Extended Aeration with Effluent to

Table 6-1. Domestic point sources in the Estero Bay Watershed.

MAP ID	FACILITY ID	SECONDARY BASIN	TERTIARY BASIN	NAME	TREATMENT
D15	FLA014692	11	1	Bonita Resort and Club	Extended Aeration to Drainfield
D16	FLA014442	7	7	Bonita Springs Country Club	Extended Aeration to Perc Ponds
D17	FLA014413	8	1	Bonita Springs Middle School	Extended Aeration to Perc Ponds
D18	FLA014475	8	5	Bonita Springs Trailer Park	Extended Aeration
D19	FLA014443	7	6	Bonita Springs Water Reclamation	Oxygenation Ditch with Filtration and Chem Add
F20	FLA014456	8	4	Bonita St. James Village	Extended Aeration with Dual Absorption
D22	FLA014555	8	1	Center of Bonita Springs	Extended Aeration
D26	FLA014477	8	4	Citrus Park, North	C/s to Polishing Pond & 2 Perc Ponds
D38	FLA014539	8	3	Econo Lodge	Extended Aeration
D39	FLA014608	11	1	Egret Condominiums WWTP	Extended Aeration to Drainfield
D42	FLA014533	8	4	Forest Mere, STP	Extended Aeration
D49	FLA014572	8	2	Greyhound Industrial Park	Extended Aeration
D51	FLA014454	7	7	Gulf Coast Camping Resort	Extended Aeration
D53	FLA014600	11	1	Hickory Shores Condominium	Extended Aeration to Drain Field
D55	FLA014541	8	2	Hunter's Ridge WWTP	Extended Aeration Process
D59	FLA014681	8	3	Imperial Bonita Estates WWTP	Extended Aeration to Perc Pond
D60	FLA014525	8	3	Imperial Bonita Estates WWTP	Extended Aeration Polishing and Dual
D61	FLA014663	7	7	Imperial Harbor, Domestic	Contact Stabilization
D64	FLA014467	8	3	Jones Mobile Village	Extended Aeration
D66	FLA014449	8	4	L. C. M. Sewer Authority	Extended Aeration
D68	FLA014473	6	3	Leisure Time Campsites & Club	Extended Aeration to Absorption Field
D69	FLA014438	8	1	Limetree Campsites	Extended Aeration
D70	FLA014490	6	3	Lucky 48 Condo.	Extended Aeration to Drainfield
D71	FLA014549	8	6	Mana Christian	Extended Aeration to Perc Ponds
D72	FLA014579	2	6	Mangold's Motel	Extended Aeration to Drainfield
D76	FLA014584	8	6	Morton Grove Apartments	Extended Aeration
D77	FLA014627	8	2	Naples - Ft. Myers Kennel Club	Extended Aeration to Ret Pond
D78	FLA014459	8	2	Oak Creek Trailer Park	Extended Aeration to Retention Pond
D80	FLA014495	11	1	Palm Bay Estates/Hickory Point	Extended Aeration to Drainfield
D82	FLA014575	8	6	Pine Haven Condo.	Extended Aeration to Perc Ponds
D86	FLA014439	8	3	River Terrace Condo.	Extended Aeration to Drainfield
D90	FLA014514	7	6	San Carlos Estates Villas	Extended Aeration to Absorption
D99	FLA014531	8	4	Southern Pines	Extended Aeration
D101	FLA014457	8	6	Spanish Wells	Extended Aeration
D102	FLA014415	8	1	Spring Creek Elementary School	Extended Air w/effluent to Drainfield
D106	FLA014480	8	1	Sunshine Foodway	Extended Aeration
D108	FLA014673	8	1	Three "S" Disposal	C/s to D/f
D112	FLA014482	8	1	Vanderbilt Lakes	Extended Aeration/cs
D113	FLA014516	8	1	West Beach Road Plaza	Extended Aeration Mode
D116	FLA014666	6	1	Wind Song Condominium	Extended Aeration to Drainfield
D118	FLA014564	8	6	Worthington WWTP	Extended Aeration
D11	FLA014571	11	1	Bonita by the Sea	Rbc to D/f
D103	FLA014639	7	1	Spring Creek Estates	Extended Aeration
D30	FLA014665	6	5	Covered Wagon Trailer Park	Extended Aeration to Perc Pond

Table 6-1. Domestic point sources in the Estero Bay Watershed.

MAP ID	FACILITY ID	SECONDARY BASIN	TERTIARY BASIN	NAME	TREATMENT
D33	FLA014545	6	5	Cypress Bend R.V.Resort	Extended Aeration to Perc Ponds
D40	FLA014416	6	6	Estero High School	Extended Aeration to Dual Perc Ponds
D46	FLA014669	6	3	Fountain Lakes WWTP	Extended Aeration to Dual Percolation
D74	FLA014636	6	5	Mariners Cove MHP	Extended Aeration to P/e Pond
D87	FLA014569	6	5	Riverwoods Plantation R. V. Park	Contact Stabilization with Perc Pond
D92	FLA014560	5	4	San Carlos WWTP	Extended Aeration in Parallel with C/s
D95	FLA014540	5	5	Shady Acres Mobile Home	Extended Aeration
D96	FLA014532	5	1	Shady Acres Mobile Home Subdivision	Extended Aeration Process
D104	FLA014655	7	1	Spring Creek Village	Extended Aeration to Dual Percolation
D105	FLA014577	6	5	Sunny Grove Park, Inc.	Extended Aeration to Spray Irrigation
D107	FLA014653	6	5	Tahiti Mobile Village	Extended Aeration to Retention Pond
D109	FLA014519	6	8	Three Oaks WWTP	Extended Aeration to Golf Course Irrigation
D1	FLA014538	4	4	Airport Woods Commerce Center	Bio-tower/cs
D2	FLA014528	11	1	Amberwood/Kellybrook	Extended Aeration
D24	FLA014527	3	9	Charter Glade Medical Corp.	Extended Aeration
D27	FLA014617	3	8	Coral Woods	Extended Aeration Process Plant
D29	FLA014550	6	7	Corkscrew Woodlands	Extended Aeration with Multiple Perc Ponds
D31	FLA014651	4	4	Crews Sanitation Co.	Lime Stabilization Process Septage
D32	FLA014505	4	3	Cross Creek Country Club	Extended Aeration to Filters
D34	FLA014616	2	10	Daniels Crossing Shopping Center	Extended Aeration Process Plant
D35	FLA014530	4	4	Danport Center	Contact Stabilization with Effluent
D36	FLA014496	2	5	Davis Lake Condominium WWTP	Extended Aeration
D37	FLA014498	4	1	Eagle Ridge WWTP	C/s with Eff. To Spray Irrigation
D43	FLA014478	2	3	Forest Utilities, Inc.	Complete Mix/recovered Water to Golf
D48	FLA014458	5	4	Granada Lakes RV WWTP	Extended Aeration to Perc Ponds
D56	FLA014695	4	4	I-75 Rest Area	Extended Aeration Treatment Process
D63	FLA014559	4	4	Jetport Interstate Commerce Park	Extended Aeration
D65	FLA014466	1	2	Kelly Greens STP	Extended Aeration
D67	FLA014501	2	6	Laurel Oaks WWTP	Extended Aeration to D/f
D75	FLA014511	3	9	McGregor Baptist Church	Rotordisk to Drainfield
D83	FLA014691	2	10	Pinebrook Lakes	Extended Aeration
D84	FLA014507	5	1	Pink Shell Island Shores	Extended Aeration Process
D93	FLA014481	1	2	Sanibel Harbour Resort	Contreat
D94	FLA014504	11	1	Santa Maria Resort	Contreat (T/f to C/s)
D98	FLA014567	2	10	Six Mile Commercial Park	Extended Aeration to Drainfield
D100	FLA014420	4	4	Southwest Florida International Airport	Extended Aeration with Effluent as
D115	FLA014437	6	6	Wildcat Run WWTP	Contact Stabilization Treatment Plant
D117	FLA014441	5	1	Woodsmoke Camping Resort	Extended Aeration to Polishing & Perc Ponds
D23	FLA014660	1	2	Century 21 Mobile Com	C/s to Retention Pond

Table 6-1. Domestic point sources in the Estero Bay Watershed.

MAP ID	FACILITY ID	SECONDARY BASIN	TERTIARY BASIN	NAME	TREATMENT
D25	FLA014558	1	1	Chippendale	Extended Aeration to D/f
D45	FLA014598	3	4	Fort Myers Campground	Extended Aeration to Single Perc Pond
D50	FLA014634	1	2	Gulf Air Travel Park	Extended Aeration with Effluent to
D73	FLA014436	1	5	Mariner's Lodge	Extended Aeration
D91	FLA014682	1	5	San Carlos Trailer Park	Extended Aeration to Drainfield
D111	FLA014631	1	2	Tropicana Mobile Manor	C/s to Retention Pond
D3	FLA014687	3	4	America Outdoors Trvl. Tr. Pk.	Extended Aeration to Perc Pond
D8	FLA014499	11	1	Black Island Resort/Days Inn	Extended Aeration/cs to Afs
D44	FLA0144215	2	5	Fort Myers Beach STP	C/s to Reuse System with Perc Pond
D47	FLA014542	4	4	Gateway Services District I	Extended Aeration, Effluent to Dual
D62	FLA014520	1	2	Indian Creek Shopping Center	Extended Aeration Process
D89	FLA014620	4	4	S.W. FLA. Regional Convention Ctr.	Extended Aeration
D110	FLA014630	2	10	Tip Top Trailer Village	Extended Aeration to Perc Pond to D/f
D114	FLA014553	4	3	West Ridge Villas	Extended Aeration
D88	FLA014583	11	1	Royal Pelican Association, Inc.	Extended Aeration Process
D57	FLA014136	9	3	Immokalee Stockade STP	Extended Aeration to Ret Pond
D58	FLA014132	10	3	Immokalee WWTP	Oxidation Ditch (Extended Aeration)
D28	FLA014233	9	2	Corkscrew Swamp Sanctuary	Experimental
D81	FLA014492	1	2	Palmetto Palms RV Resort Condo	
D21	FLA014547	3	6	Brookshire Village STP	Contact Stabilization Process Wastewater
D41	FLA014484	5	4	Fiddlesticks Country Club	Contact Stabilization with Effluent
D52	FLA014602	3	6	Gulf Coast Hospital	Extended Aeration to Multiple Absorption
D79	FLA014486	2	5	Paddle Creek	Contact Stabilization
D97	FLA014570	1	2	Siesta Bay RV Park	Extended Aeration to Drainfield

Table 6-2 presents a summary of the industrial point sources found in the Estero Bay Watershed. Plate 6-1 presents the locations of the these point sources. The map ID's in Table 6-2 correspond to the map ID's in Plate 6-1.

The Estero Bay Watershed contains 13 industrial point sources permitted by FDEP for discharge to waterbodies or lands within the watershed area. Nearly all of these are located in the Six-Mile Cypress Slough, Imperial River, and Estero River basins.

Table 6-2. Industrial point sources in the Estero Bay Watershed.

MAP ID	FACILITY ID	SECONDARY BASIN	TERTIARY BASIN	NAME	TREATMENT
I1	FLA014657	3	6	ACS II, Inc.	100% Recycling Facility
I2	FLA014626	4	4	Alamo Rent-A-Car	Recycle Car Wash
I3	FLA017124	11	1	Bay Beach Stormwater	Stormwater Discharge System
I4	FLA042102	3	11	Fort Myers Membrane Softening WTP	Spray Irrigation Disposal

Table 6-2. Industrial point sources in the Estero Bay Watershed.

I5	FLA014647	4	1	Fort Myers Mine (FL Rock)	No Treatment. No Surface
I6	FLA014554	7	7	Gulf Coast Camping Resort	R/O Reject to On-site Dom
I7	FLA014633	4	6	Gulf Disposal, Inc.	Total Recycle Truck Wash
I8	FLA014674	6	6	Gulf Environmental Services-Corkscrew	Membrane Softening Concentrate
I9	FLA038792	8	1	Harbor Utilities WTP	RO Reject Stream
I10	FLA014640	6	8	Harper Bros., Alico Quarry	Gp-No Surface Water Discharge
I11	FLA014654	4	4	Southwest Florida Pipeline Co.	Collection of Tank Drawdown
I12	FLA014427	4	4	Southwest Florida Regional Airport	Oil Water Separator, Disc
I13	FLA014611	8	4	Tisch Coin Laundry	Trickling Filter with Effluent

6.2 Stormwater Outfall Inventory

Lee County has compiled a list of stormwater outfalls and NPDES permitted locations. Plate 6-2 presents the distribution of these outfalls. The Imperial River, Ten-Mile Canal, Six-Mile Cypress Slough, and Hendry Creek basins contain the majority of these outfalls. Lee County staff have communicated that this list is not comprehensive but does represent most of the outfalls in the Lee County portion of the Estero Bay Watershed.

6.3 Water Quality

Lee County staff have been monitoring water quality within Estero Bay and its tributaries since the early 1990s (Keith Kibbey, pers. comm., 1998). A number of tributary sampling stations have been added over the years. Currently, the following lists the sampling stations being visited on a monthly basis:

- Ten-Mile Canal - 7 stations
- Six-Mile Cypress Slough - 6 stations
- Estero River - 4 stations
- Imperial River - 5 stations
- Spring Creek - 3 stations
- Hendry Creek - 3 stations
- Mullock Creek - 2 stations.

Plate 6-3 presents the locations of these monitoring stations. The following discussion focuses on a comparison of the water quality differences and similarities among the seven basins that are currently being monitored. Appendix B presents the within-basin data for each of the seven basins.

Specific Conductance - The influence of year-to-year variation in rainfall can clearly be seen in the specific conductance data presented in Figure 6-1. The extremely high rainfall in 1995 resulted in depressed specific conductance in all seven of the basins monitored. Spring Creek is consistently among the highest specific conductances, while Mullock Creek and Six-Mile Cypress Slough reflect consistently lower conductances. Specific conductance in the Estero River is also consistently high in comparison to the other basins. The conductance values observed are typical for coastal oligohaline streams.

Dissolved Oxygen - There is considerable temporal variation in dissolved oxygen (DO) concentrations observed in all seven basins (Figure 6-2). In 1992 and 1993, the DO concentrations were higher than those observed during the period 1994-1997. Inspection of potential sampling artifacts should be completed as such changes are often the result of methodologic influences. The mean DO concentrations, taken at mid-day, are typically in the range of 2 to 4 mg/L.

BOD - Despite the year-to-year variation in rainfall, the temporal variation in BOD concentrations was quite small (Figure 6-3). The annual mean BOD concentrations are typically less than 3 mg/L. The BOD concentrations in Six-Mile Cypress Slough were usually among the highest; while both Ten-Mile Canal and Estero River BOD concentrations are typically among the lowest.

Total Nitrogen - As was observed for BOD, the annual variation in total nitrogen (TN) concentrations was relatively small (Figure 6-4). There was no apparent impact by the high 1995 rainfall amounts on TN concentrations in any of the basins sampled. Average annual TN values were usually less than 1 mg/L, which compares well with the median (1.32 mg/L) observed in southern Florida streams (Friedmann and Hand, 1992). While Ten-Mile Canal is often among the highest, there is little variation in average annual TN concentrations among the seven basins sampled.

Nitrite + Nitrate Nitrogen - Nitrite + nitrate nitrogen (NO_2 + NO_3) concentrations reflect the availability of dissolved inorganic nitrogen to algal uptake in coastal waters. There was considerable year-to-year and among basin variation in NO_2 + NO_3 concentrations (Figure 6-5). Typical values ranged from less than 0.05 mg/L to greater than 0.20 mg/L. These values are similar to the median of 0.11 mg/L observed in southern Florida streams and rivers.

Ammonia Nitrogen - Nearly all of the average annual ammonia nitrogen concentrations were less than 0.10 mg/L (Figure 6-6). Estero River typically has the lowest ammonia nitrogen concentrations, while Mullock Creek, Hendry Creek, and Ten-Mile Canal concentrations are usually among the highest. As was observed for TN, the high 1995 rainfalls did not apparently influence the ammonia concentrations in any of the basins sampled.

Total Kjeldahl Nitrogen - There was very little among-basin or temporal variation in the total Kjeldahl nitrogen concentrations observed during the period of record (Figure 6-7). Annual average concentrations were nearly always less than 1.0 mg/L.

Total Phosphorus - Total phosphorus (TP) concentrations also did not vary either among basins or from year-to-year, with the exception of one suspiciously high value observed in Hendry Creek in 1990 (Figure 6-8). Both Hendry Creek and Ten-Mile Canal typically displayed the highest TP concentrations. Most average annual values were in the range of 0.1 to 0.3 mg/L. These values are somewhat high in comparison to the median of 0.13 mg/L reported for south Florida streams and rivers by Friedmann and Hand (1992).

Ortho-phosphorus - Ortho-phosphorus concentrations reflect the amount of inorganic dissolved phosphorus available or algal uptake. Most values observed over the period of record in the seven basins were less than 0.05 mg/L (Figure 6-9). Hendry Creek and Six-Mile Cypress Slough typically had the highest ortho-phosphorus concentrations in the study area. Conversely, Estero River and Ten-Mile Canal were usually among the lowest.

Total Suspended Solids - Total suspended solids (TSS) concentrations reflect the amount of suspended material being delivered by a waterway to the receiving waterbody. The TSS concentrations did vary appreciably among the seven basins sampled (Figure 6-10). Mullock Creek, Spring Creek, and the Estero River reflected high TSS concentrations during the study period. In contrast, Hendry Creek typically had the lowest TSS concentrations.

Turbidity - Turbidity values varied significantly among the seven basins sampled (Figure 6-11). Mullock and Spring creeks were typically highest, while Ten-Mile Canal and Six-Mile Cypress Slough displayed low turbidity values. The average annual turbidity values were routinely less than 4 NTU in all basins.

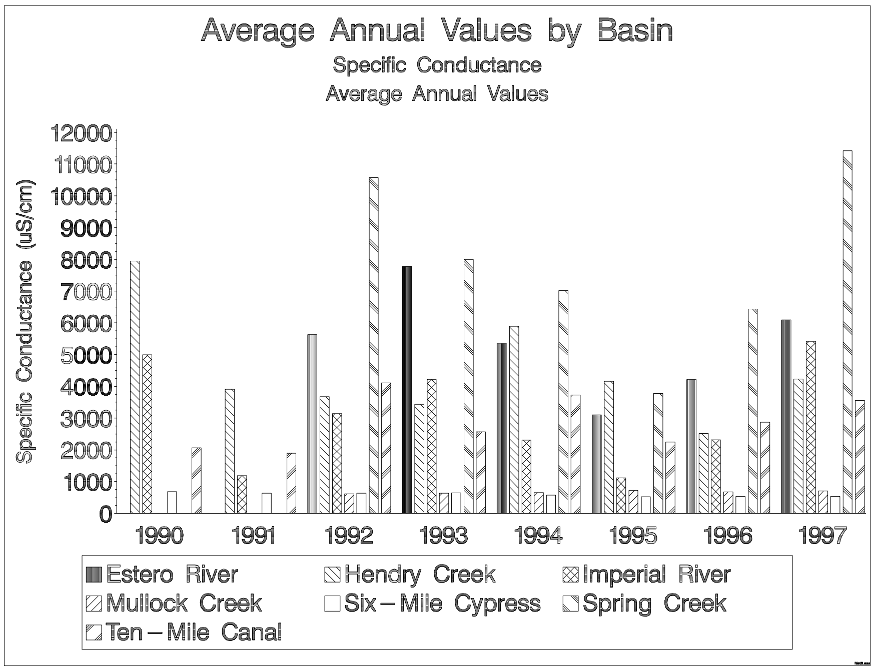

Figure 6-1. Average annual specific conductance observed in seven tributaries to Estero Bay. Data collected by Lee County.

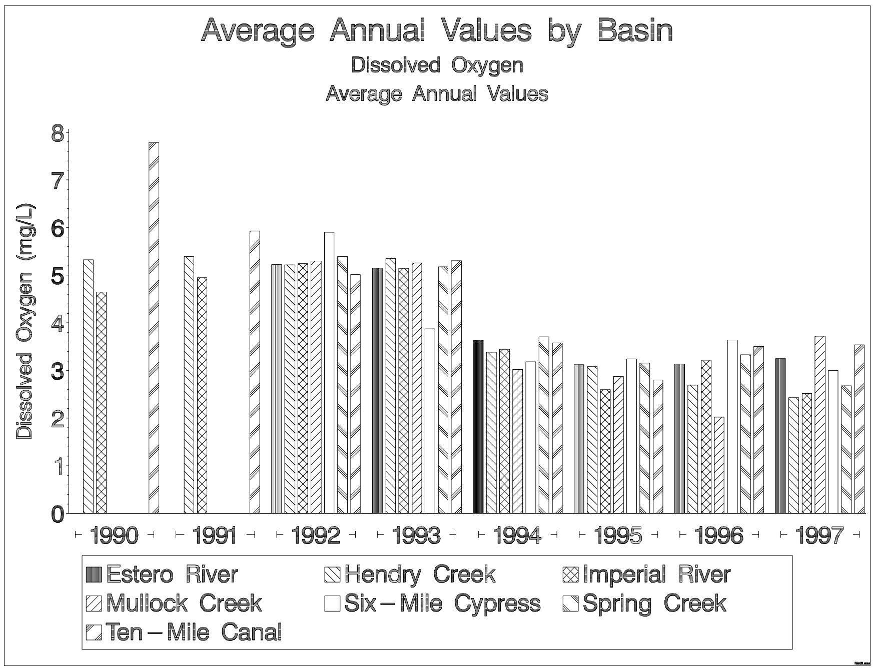

Figure 6-2. Average annual dissolved oxygen concentrations observed in seven tributaries to Estero Bay. Data collected by Lee County.

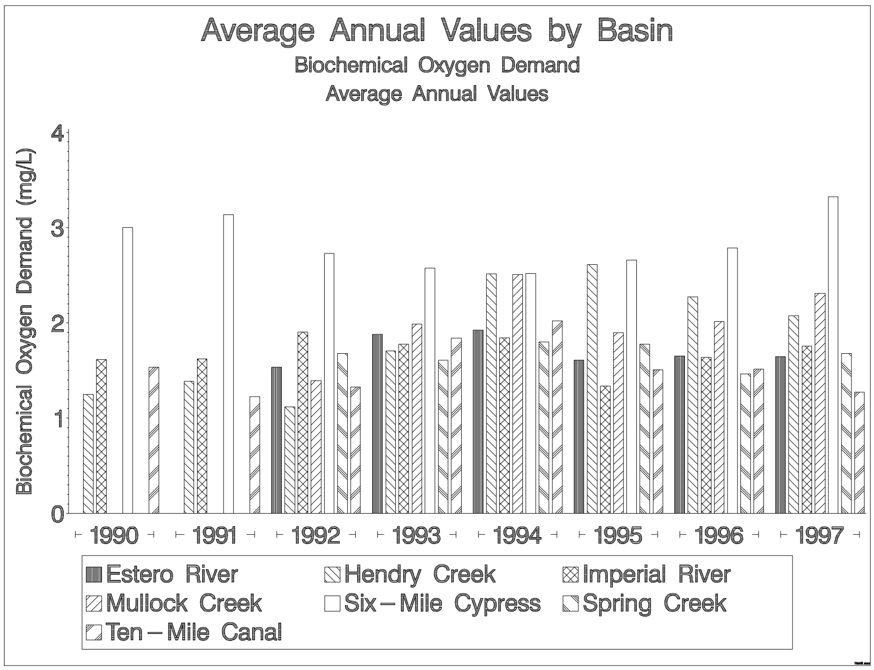

Figure 6-3. Average annual BOD concentrations observed in seven tributaries to Estero Bay. Data collected by Lee County.

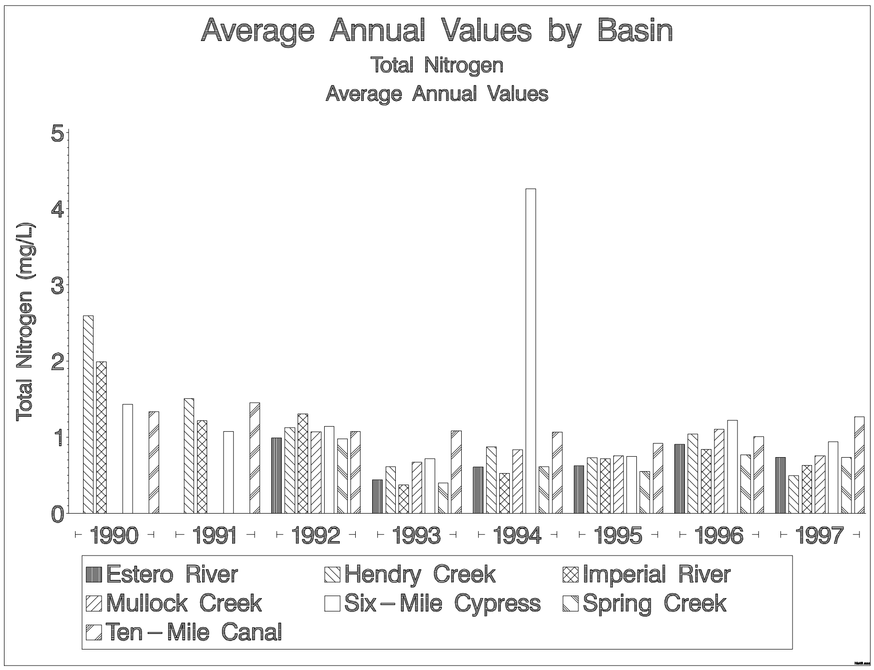

Figure 6-4. Average annual total nitrogen concentrations observed in seven tributaries to Estero Bay. Data collected by Lee County.

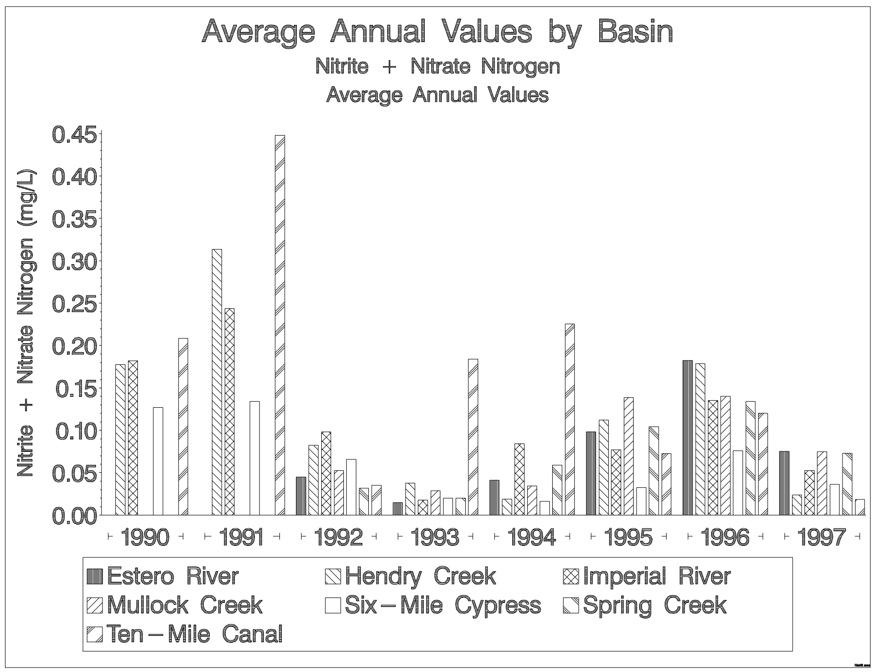

Figure 6-5. Average annual nitrite + nitrate nitrogen concentrations observed in seven tributaries to Estero Bay. Data collected by Lee County.

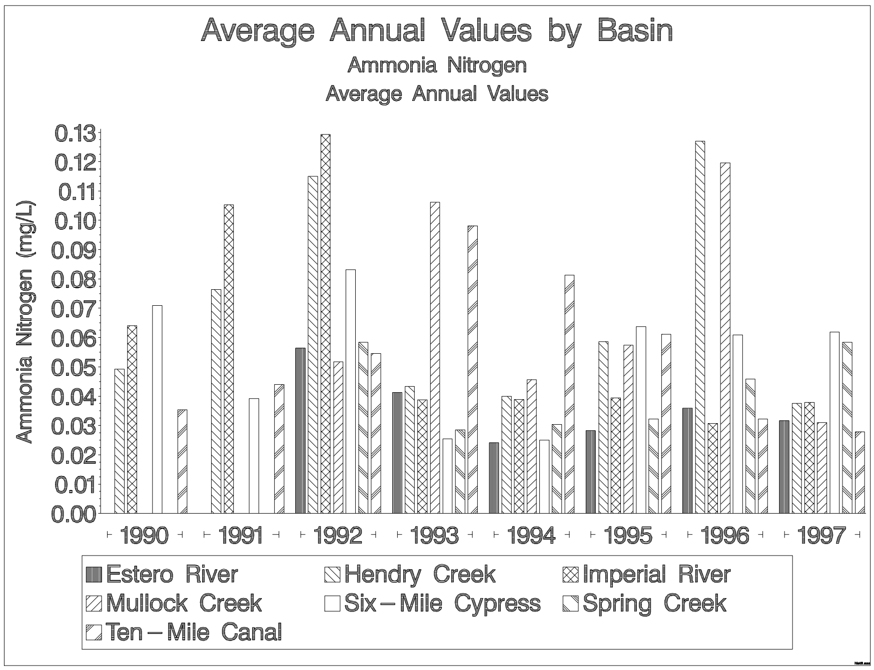

Figure 6-6. Average annual ammonia nitrogen concentrations observed in seven tributaries to Estero Bay. Data collected by Lee County.

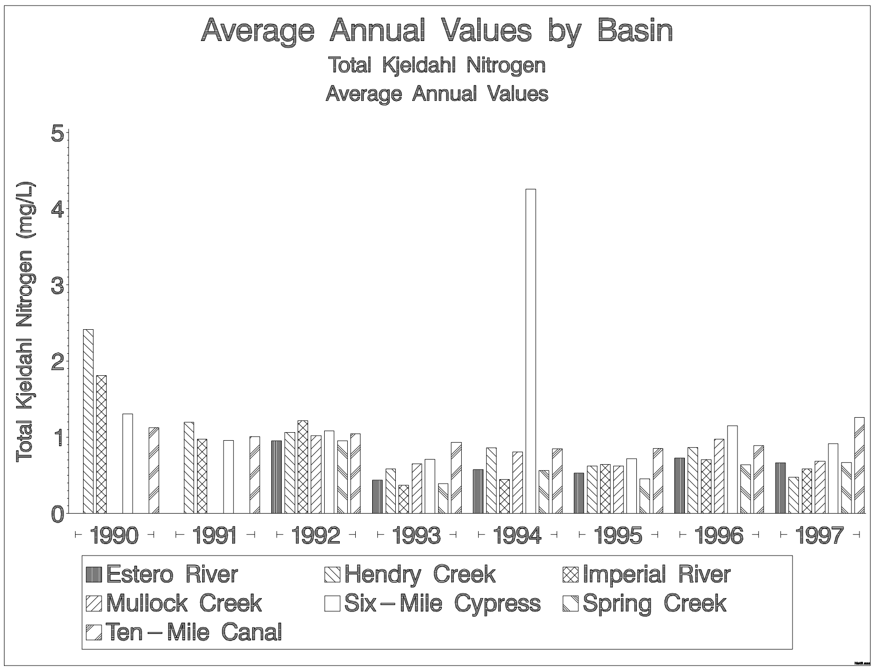

Figure 6-7. Average annual total Kjeldahl nitrogen concentrations observed in seven tributaries to Estero Bay. Data collected by Lee County.

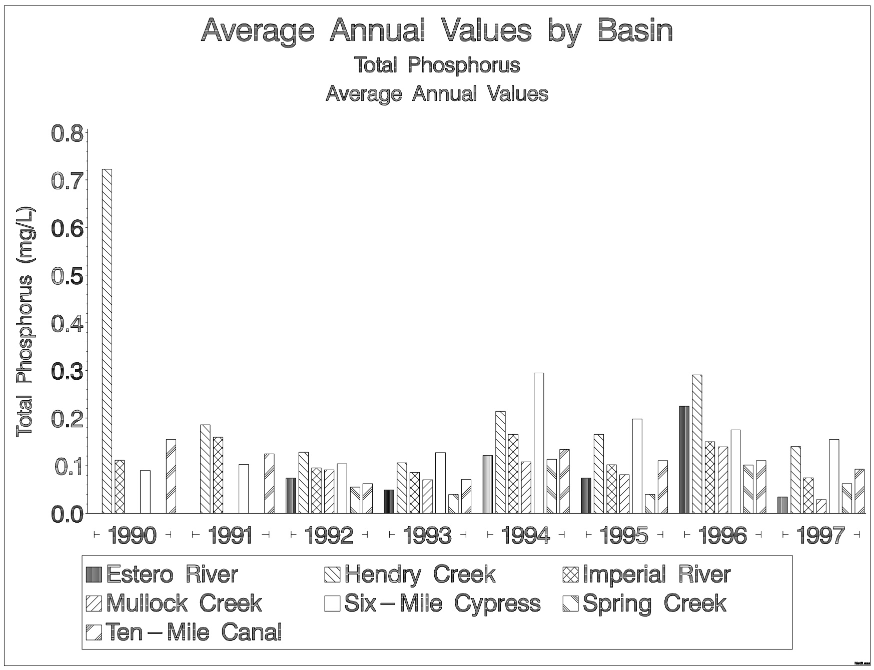

Figure 6-8. Average annual total phosphorus concentrations observed in seven tributaries to Estero Bay. Data collected by Lee County.

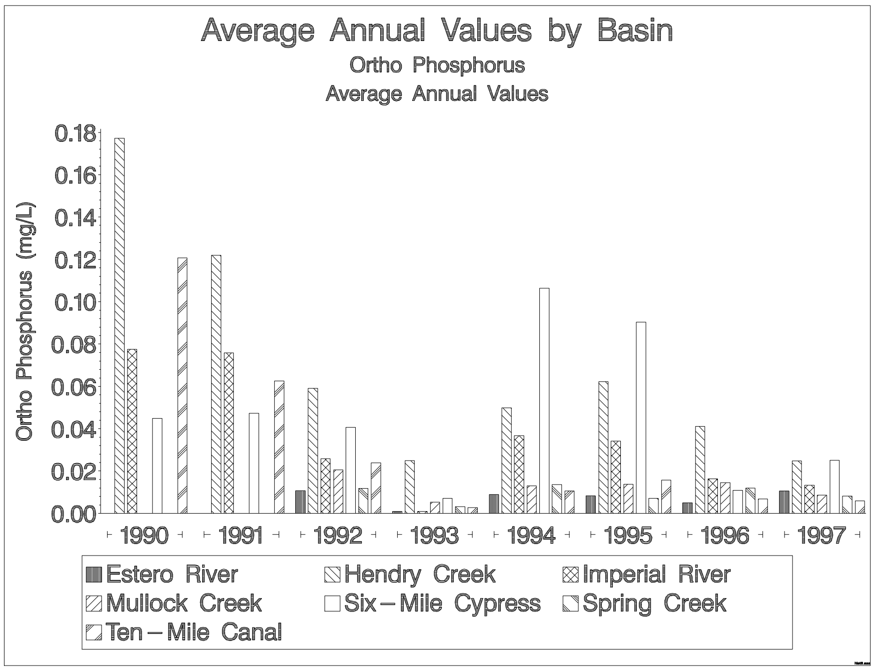

Figure 6-9. Average annual ortho- phosphorus concentrations observed in seven tributaries to Estero Bay. Data collected by Lee County.

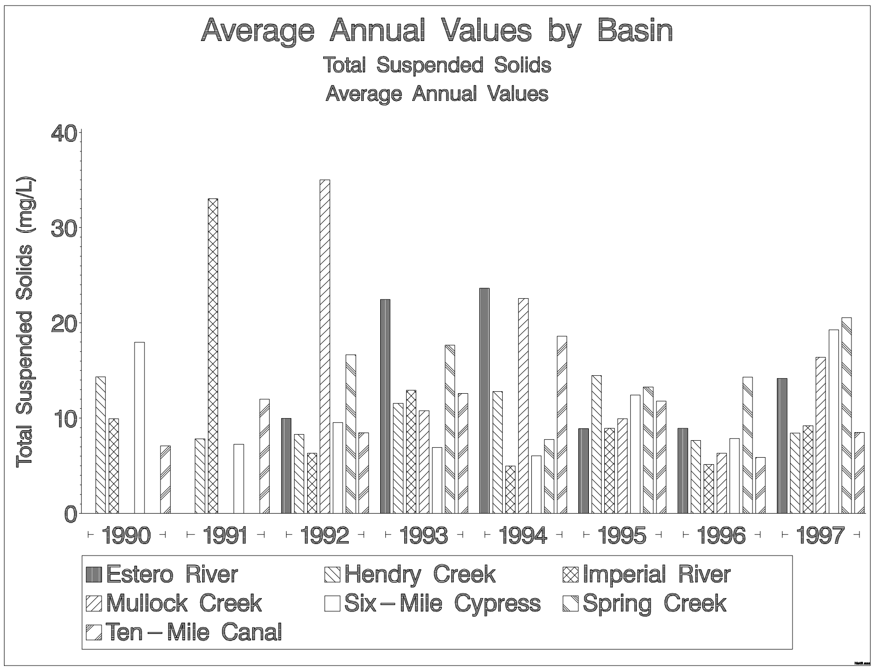

Figure 6-10. Average annual total suspended solids concentrations observed in seven tributaries to Estero Bay. Data collected by Lee County.

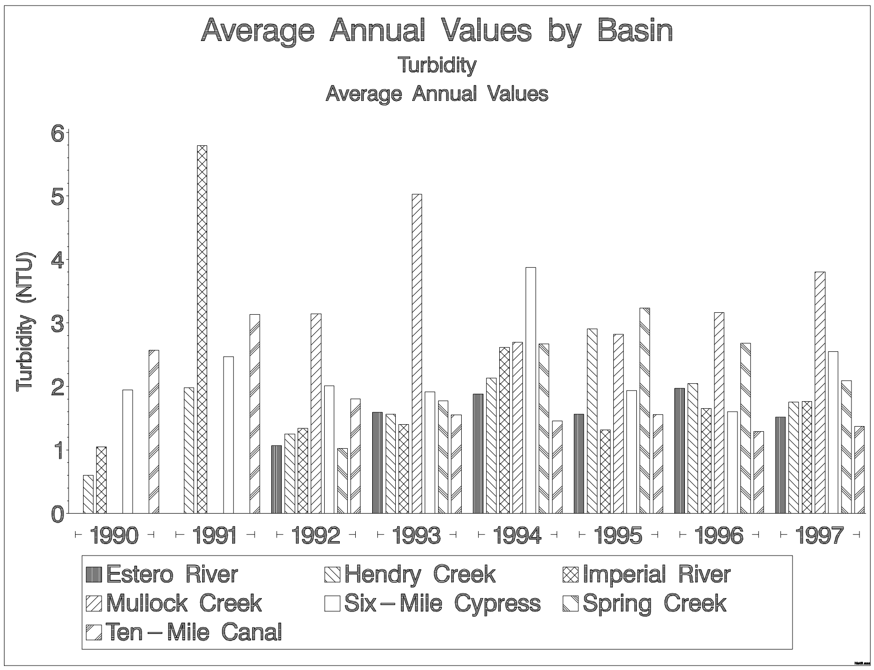

Figure 6-11. Average annual turbidity concentrations observed in seven tributaries to Estero Bay. Data collected by Lee County.

6.4 Wetland Risk

The Estero Bay Watershed contains several areas of locally and regionally significant habitats and wetlands upon which numerous species of rare wildlife and plants depend. Many of these areas are potentially sensitive to disturbances and alterations to land use, land cover, hydrology, water quality, and other factors discussed in this report. The following discussion and accompanying plates identify, illustrate, and describe these sensitive areas, methods used to delineate them, and potential threats to the areas.

Several sensitive areas are currently in conservation-preservation areas, some are in proposed conservation-preservation areas, but many are not protected by specific conservation easements or designations. Several state-wide FGFWFC analyses have identified and delineated sensitive or significant habitats and wetlands within the Estero Bay Watershed. Areas delineated include “priority wetland habitats,” “strategic habitat conservation areas,” “biodiversity hotspots,” and “potential habitat areas.” The accompanying plates are generated from Florida Game and Fresh Water Fish Commission digital databases. The data are summarized in the Cox et al. (1994) report *Closing the Gaps in Florida’s Wildlife Habitat Conservation System* and the Kautz et al. (1994) report, *Mapping Wetland Habitats of High Priority to Endangered and Threatened Species in Florida*.

Strategic Habitat Conservation Areas

Habitat conservation areas were delineated by Cox et al. (1994) so as to provide the minimum amount and quality of habitat to sustain at least ten populations of two-hundred individuals for forty-four wildlife taxa. Where these populations could not be supported on existing, public, conservation lands, conservation areas were delineated on suitable private lands. Strategic habitat conservation areas were also generated for rare plant and animal communities as well as for individual species of plants. The combination of these delineations in the Estero Bay Watershed is shown here. These habitat conservation areas generally correspond with the large, contiguous biodiversity hotspot areas described below.

The strategic habitat conservation areas within the Estero Bay Watershed are concentrated in five areas (Plate 6-4). The largest area consists of the Flint Pen Strand, Corkscrew Marsh, and Lake Trafford portions of the Corkscrew Regional Watershed. These areas are a mixture of pine flatwoods, wet prairies, marshes, cypress swamps, and agricultural lands.

Strategic habitat conservation areas are also grouped along the shores of Estero Bay, the Estero River, and the Ten-Mile Canal. These areas consist of coastal wetlands and near-by uplands including some scrub habitats. The third aggregation of strategic habitat conservation areas is in and around Six-Mile Cypress Slough. Six-Mile Cypress Slough is an area of pine flatwoods, transitional hardwoods, wet prairies, and cypress and melaleuca sloughs.

The fourth and fifth groups of strategic habitat conservation areas are located northeast of Alico Road and south of Halfway Pond. These are areas of pine flatwoods, cypress swamps, and marshes with interspersed agricultural fields. Marshes and wet prairies, however, are important factors behind the designation of these communities as strategic habitat conservation areas.

The habitats of the Florida black bear (*Ursus americanus floridanus*), Florida Panther (*Felis concolor coryi*), wood stork (*Mycetaria americana*), and American swallow tailed kite (*Elinoides forficatus*) are primary targets of protection in designated strategic habitat conservation areas around in the Flint Pen Strand, Corkscrew Swamp, and Lake Trafford areas. The mottled duck (*Anas fulvigula*), limpkin (*Aramus guarauna*), snowy egret (*Egretta thula*), short tailed hawk (*Buteo brachyurus*), eastern indigo snake (*Drymarchon corais couperi*), and several other wading bird species are also present in this area. Big Cypress fox squirrel (*Sciurus niger avicenna*) habitat comprises a small portion of the Flint Pen Strand to Lake Trafford group of strategic habitat conservation areas.

Red cockaded woodpeckers (*Picoides borealis*) occupy some of these areas, though they are more prevalent in habitats to the south, in Collier County. The nesting red cockaded woodpecker colony that once existed within Corkscrew Swamp Sanctuary is no longer active (J.E. Carlson, Corkscrew Sanctuary, personal communication). However, the PBS&J authors of this study and FGFWFC and USFWS biologists observed red cockaded woodpecker cavities on SFWMD land, immediately west of the Sanctuary in 1998.

The clusters of strategic habitat conservation areas east of Southwest Florida International Airport and south of S.R. 82 are of primary importance as wading bird habitats. The group of strategic habitat conservation areas around the Six-Mile Cypress preserve are primarily wetlands. They are important to several wetland dependent species. The final clusters of strategic habitat areas are located on the shores of Estero Bay. The Bay itself has supported brown pelican, tricolored heron (*Egretta tricolor*), snowy egret, and great egret (*Casmerodius albus*) rookeries and bald eagle (*Haliateetus leucocephalus*) nesting and perching areas.

Exotic vegetation invasion is a notable threat to several of these strategic habitat conservation areas. Development will likely have a greater effect on the strategic conservation areas within the Estero Bay Watershed, however. Several large portions of the strategic habitat conservation areas along Alico Road, and Corkscrew Road, east of I-75, are currently undergoing residential, commercial, or mining development, and additional development is proposed in this portion of the watershed. The high prices of recent agricultural land purchases well east of the new developments and quarries suggest that development pressures are strong several miles east of the I-75 corridor as well.

Biodiversity Hotspots

The strategic habitat conservation areas above delineate areas essential to sustain rare plants, animals, and natural communities on a state wide level. The delineated areas do not include other habitats that might be important for sustaining local populations of rare species or locally rare valuable resources. We have chosen to describe many of these locally important resources together with the strategic habitat conservation areas and resources of state wide importance above.

Cox et al. (1994) generated biodiversity hotspots by overlaying important habitats of forty four focal taxa, wading birds, and important natural communities. These overlay habitats were then divided into three classes based on the number of species that would find the habitat suitable. Class 1 areas depict habitats that are suitable for three to four focal species. Class 2 and 3 areas depict habitats that are suitable for five to six focal species and seven or more focal species respectively.

The majority of the Class 1 (three to four focal species) habitats in the Estero Bay Watershed are associated with agricultural lands. The Class 1 areas are primarily natural areas adjacent to the agricultural lands or are fallow agricultural lands or pastures. Class 2 lands are also found in close proximity to agricultural and other disturbed lands. These Class 1 and 2 lands serve as important buffers for some of the Class 3 habitats.

Class 3 habitats in the eastern portion of the watershed (Plate 6-5) generally correspond with the strategic habit conservation areas described above and in Plate 6-4. These areas are primarily wetlands and adjacent uplands, both because wetlands are important to Southwest Florida's wildlife and because many of the watershed's uplands have been converted to agriculture, mining, or development. Like the strategic habitat conservation areas in the eastern portion of the watershed, the greatest threat to these Class 3 habitats comes from development and invasive exotic vegetation. In the western portion of the watershed, Class 3 habitats occupy much of the Estero Bay shoreline. These habitats are primarily coastal wetlands and the adjacent uplands. Many of these lands are located within existing conservation areas, but uplands outside of these conservation areas are particularly prone to development.

Priority Wetland Habitats

The FGFWFC generated the priority wetland habitats by aggregating predictive habitat maps for thirty five wetland dependent species that are listed as Endangered, Threatened, or Species of Special Concern by the FGFWFC. Their methods were published in Kautz et al. (1994), *Mapping Wetland Habitats of High Priority to Endangered and Threatened Species in Florida*. The mapping effort distinguishes between numbers of focal, wetland-dependent species found in upland and wetland areas (Plate 6-6).

This analysis highlights the fact that one of the most severe threats to the function and value of wetland habitats in the Estero Bay Watershed may be the loss of associated and interdependent upland habitats. For example, the analysis depicts large areas of: 1.) wetlands with several focal species; and 2.) uplands with wetland dependent species in the vicinity of the I-75 corridor and the southeastern Estero Bay shoreline. Both areas are particularly prone to development, and residential, commercial, and mining development is proposed or under construction along much of the I-75 corridor.

The small or isolated priority wetland habitats are also particularly threatened by agricultural and suburban development. Small wetlands are typically isolated from surrounding natural habitats when development occurs. In the absence of development, invasive exotic vegetation frequently comes to dominate the edges of these small wetlands too. Cypress wetlands surrounded by agricultural fields, citrus groves, or residential communities are a common feature of the Estero Bay Watershed. The core or interior portions of large wetland systems are often buffered from surrounding land use or exotic vegetation by the sheer size of the wetland system. The interiors of small wetlands do not benefit from this self-buffering effect.

Potential Florida Panther Habitat

Cox et al. (1994) generated the potential Florida panther habitats shown here by first establishing “preferred” and “secondary” habitat types using a land cover data base. Preferred habitat types included pineland, hardwood hammocks, and cypress swamps. Secondary habitat types included hardwood swamps, dry prairies, oak scrub, and certain other habitat types that may not be used directly by panthers, but that probably influence the presence of panthers in an area. Examples of secondary habitats are those that contribute to the support or presence of panther prey species.

The probable panther habitats were delineated by identifying preferred land cover and eliminated patches of these covers that were less than 0.4 km^2. Within 1 km of these large, preferred land cover areas, all patches of preferred land cover less than 0.4 km^2 and all patches of secondary land cover were identified and combined with the larger patches to produce the preliminary habitat boundaries. Preliminary habitats that fell within 300 m of large (greater than 0.4 km^2) areas of barren land were eliminated to account for panther avoidance of barren lands (Cox et al., 1994). This produced their final habitat delineations.

Potential panther habitat in the Estero Bay Watershed is primarily a map of cypress swamps and pine flatwoods, as hardwood hammocks in the watershed tend to be small (Plate 6-7). Local hunters have long considered Southwest Florida’s hardwood hammocks to be deer and panther habitat, however. Large areas of potential panther habitat occur within and in close proximity to Flint Pen Strand, Corkscrew Swamp, and the edges of Corkscrew Marsh.

Other large areas occur south of Alico Road, around Southwest Florida International Airport, and in the vicinity of Colonial Boulevard and I-75. More isolated areas of potential panther habitat occur between Estero Bay and Tamiami Trail, though highways and development probably limit the support these areas currently provide to the panther population. Development and the expansion of exotic vegetation have already impacted some of the habitats delineated in the watershed. The majority of delineated habitats are still somewhat intact and providing potential support to the panther population, however.

Potential Wood Stork Habitat

The potential wood stork habitat shown here was generated by Cox et al. (1994) using the assumption that wood storks primarily forage within 30 km of their breeding colonies. The wetlands identified in the Estero Bay Watershed are primarily cypress swamps and sloughs, wet prairies, freshwater marshes, and coastal marshes and mangrove swamps (Plate 6-8). These areas include a large, contiguous band of habitat formed by Camp Keais Strand, Corkscrew Marsh, Corkscrew Swamp, Flint Pen Strand, and the areas north of both Flint Pen Strand and Corkscrew Marsh. The coastal wetlands of Estero Bay comprise another large contiguous area of potential wood stork foraging habitat. Two other large contiguous areas of potential foraging habitat are situated in the mosaic of agricultural fields and wetlands east of Southwest Florida International Airport and south of S.R. 82.

The wet pine flatwoods and wet prairies that serve as wood stork foraging habitat are prone to agricultural, residential, or mining development, or invasion by exotic vegetation. Reviews of historic aerial photographs dating back to the 1940s indicate that the number of isolated marshes and wet prairies in the watershed has dramatically decreased, particularly in the area immediately west and north of Corkscrew Swamp and Corkscrew Marsh. Agricultural development appears to have been the primary cause of the historic loss of flatwoods, wet prairies, and marshes in the eastern half of the watershed. Wood stork habitat losses in flatwoods and wet prairies are likely to continue throughout the watershed as a result of residential-commercial, infrastructure, mining, and agricultural development and exotic vegetation invasions..

Potential Florida Black Bear Habitat

Cox et al. (1994) identified potential “primary” Florida black bear habitats combining pineland, oak scrub, hardwood pine, hardwood, and cypress land covers and eliminating patches that were less than 0.15 km^2. All less than 0.15 km^2 habitat areas within 1 km of greater than 0.15 km^2 habitat area were reincorporated as probable habitat areas under the assumption that the smaller areas would be utilized by bears occupying the larger nearby areas.

A secondary class of potential bear habitats was established by Cox et al. (1994) using the methodology above with dry prairie, shrub swamp, and shrub and brush land covers. They created a third category of potential bear habitat by identifying the upland 300 m of mangrove swamps excluding areas within 90 m of the Gulf of Mexico.

The potential black bear habitat is clustered in Corkscrew Swamp, Flint Pen Strand, and along the edges of the Corkscrew Marsh. Potential habitat extends north from Flint Pen Strand towards Alico Road, and a narrow, east-west oriented band of habitat connects the northern edge of Corkscrew Marsh with the habitats south of Alico Road (Plate 6-9). The Florida Natural Areas Inventory database documents black bears using the Corkscrew Sanctuary in the early 1990s. The authors of this PBS&J study observed fresh bear tracks in 1998 in the designated, potential bear habitat west of the Corkscrew Sanctuary.

To the north, there is a cluster of potential habitat in the vicinity of Southwest Florida International Airport. There is another cluster of potential habitat between the Tamiami Trail and Estero Bay, north of Spring Creek. Some new developments west of I-75 contain narrow wetland habitat corridors that bears could traverse to access this habitat on the edge of Estero Bay. I-75, however, will likely serve as a significant barrier to bears.

Some of the potential bear habitat areas immediately south of Alico Road are no longer bear habitat as they are in the process of being developed. Additional portions of these habitat areas are proposed for development. Heavy melaleuca invasion in some habitat areas close to I-75 will also decrease the habitat value of some areas in existing conditions.

Potential Big Cypress Fox Squirrel Habitat

The fox squirrel (*Sciurus niger*) occurs across Florida, but the Big Cypress fox squirrel (formerly the "mangrove fox squirrel") subspecies (*S. n. avicennia*) is confined to the area south of the Caloosahatchee River. The identification of potential Big Cypress fox squirrel habitat delineated in this report stressed the identification of pineland and dry prairie (Cox et al., 1994). Cox et al. (1994) concluded that slash pine forests were important habitats in the spring and early summer, and edges of cypress swamps were probably important in the fall and early winter. They recognized that this species was found in many habitats, with the exception of freshwater swamp interiors, and that an open understory, regardless of the canopy species, was a driving factor behind habitat suitability and this factor is not well defined in spatial databases.

Cox et al. (1994) generated these data by consolidating pineland and dry prairie land covers and eliminating patches that were less than 100 ha. Within 300 m of the remaining patches, contiguous areas of hardwood hammock, hardwood-pine, cypress swamp, hardwood swamp, and mangrove were also incorporated into the identified fox squirrel habitat areas. The resulting habitat areas within the Estero Bay Watershed are concentrated around the Tamiami Trail (Rt. 41) and I-75 corridors (Plate 6-10). Big Cypress fox squirrel habitats are frequently associated with agricultural or residential development because squirrels and developments both require uplands. There is a cluster of potential habitats in the northern portion of the watershed on the remaining open lands around Colonial Boulevard west of I-75 and within the area east of I-75 Gateway**.** Spreading melaleuca invasions together with ongoing development may have already eliminated some of these habitat areas.

Moving south through the watershed, there is a large cluster of potential fox squirrel habitat in the vicinity of Southwest Florida International Airport. There is also a large area of potential habitat between Alico Road and Corkscrew Road, south of the airport. Development in the vicinity of Florida Gulf Coast University, limerock mining, and increased melaleuca invasions have eliminated some of these potential habitats.

Another cluster of potential habitat areas is located north of Spring Creek between Estero Bay and the Tamiami Trail. Some of these areas are currently located within several large residential developments and planned communities. The habitats have undoubtably been altered, but habitat preserves, parkland, and large golf course areas within these developments may continue to serve as fox squirrel habitat.

Other smaller clusters of potential habitat are scattered throughout the Lee County portion of the watershed. Humphrey and Jodice (1992) noted that the Corkscrew Sanctuary population of Big Cypress fox squirrels may be extirpated. The authors of this PBS&J study observed fox squirrels in 1997 and 1998 on farmlands that form the Sanctuary's northern border. This population may be isolated by the deep Corkscrew marshes and swamps from habitats in the southern part of the Sanctuary, however.

6.5 Potential Agricultural and Urban Management Practices

As part of the assessment of current water quality problems in the Estero Bay Watershed, a compilation of potential agricultural and urban best management practices (BMPs) has been prepared. Overall, these practices include those designed to reduce agricultural and urban runoff, nutrient loading, and erosion. The following descriptions of the management practices are divided into agricultural and urban BMPs.

6.5.1 Agricultural BMPs

Agricultural BMPs can be divided into four groups: nutrient control, water/irrigation control, pesticide use control, and erosion control (Janicki et al., 1995). The following presents the potential agricultural BMPs applicable to central and southern Florida overall and the Estero Bay Watershed in particular. Table 6-3 summarizes these BMPs by group and by applicable crop type.

NUTRIENT CONTROL BMPs

Fencing - Fencing is the dividing or enclosing of land areas with a suitable permanent structure the acts as a barrier for livestock, game, or people. As a BMP, fencing serves to: subdivide grazing land to permit use of planned grazing systems; exclude livestock or big game from plant communities that cannot withstand grazing; distribute grazing pressures more evenly thereby enhancing the quality of runoff water; and allow deferment periods to be incorporated with brush management practices thereby improving the efficiency of water use.

Irrigation Water Management - Irrigation water management involves the determination and control of the rate, amount, and timing of irrigation water application in a planned and efficient manner through use of flow meters and potentiometers. The purpose of irrigation water management is to control the moisture environment of crops to promote the desired crop response and to minimize soils erosion, runoff, and fertilizer and pesticide movement, and to protect water quality. The manager of a conservation irrigation system must have the capability and knowledge to: determine when irrigation water should be applied based on the rate of water use by the crop and the stages of plant growth; measure or estimate the amount of water required for each irrigation, including the leaching needs; determine the normal time needed for the soil to absorb the required amount of water and how to detect changes in intake rates; adjust stream size, application rate, or irrigation time to compensate for changes in such factors as intake rate or the amount of water to be applied; recognize erosion caused by irrigation; estimate the amount of irrigation runoff from an area; and evaluate the uniformity of water application.

Land Absorption Wetland Use - This practice uses existing wetland areas as land absorption areas downstream from grazed areas so that soil and plants absorb nutrients and animal wastes.

Mulching - Mulching is the practice of applying plant residues, or other suitable materials not produced on the site, to the soil surface. Mulching conserves moisture, prevents surface compaction or crusting; reduces runoff and wind and water erosion; controls weeds; and helps establish plant cover. Mulching is applicable to soils subject to erosion on which low residue producing crops are grown, on critical areas, and on soils that have a low infiltration rate.

Nutrient Management - Nutrient management practices involve the managing of the amount, source, form, placement, and timing of applications of plant nutrients. It may include the management of plant nutrients associated with organic waste, commercial fertilizer, legume crops, and crop residues. Such practices can be applied to all lands to which materials containing plant nutrients are applied. Nutrient management practices serve to supply adequate plant nutrients for optimum (maximum economic) forage and crop yields, minimize entry of nutrients to surface and ground water, and to maintain or improve the chemical and biological condition of the soil. Proper nutrient management practices reduce the availability of nutrients that could pollute surface or groundwater by managing the application method and amounts of nutrients applied to the soil.

The NRCS Field Office Technical Guide includes several planning considerations for nutrient management practices. It should be recognized that several other listed BMPs could be grouped as a nutrient management practice (e.g., waste utilization, soil testing, plant analysis, and timing and placement of fertilizers).

Rotational Grazing - Rotational grazing is a system in which two or more grazing units are alternately rested and grazed in a planned sequence for a period of years. The rest periods may be throughout the year or during the growing season of key plants. Rotational grazing serves several purposes, including: to maintain existing plant cover or hasten its improvement while properly using the forage of all grazing units; to improve water quality and reduce erosion; to increase grazing efficiency by uniformly using all parts of each grazing unit; to provide adequate forage throughout the grazing season; to improve forage quality and increase production; to enhance wildlife habitat; to promote flexibility in the grazing program and buffer the adverse affects of drought; and to promote energy conservation by using reduced amounts of fossil fuel.

Shade Areas - Shade areas serve to lessen the need for animals to enter water for relief from heat by using trees or artificial shelters to provide shade at selected locations. Such practices minimize animal contact with surface waters and thereby serve to protect surface waters from animal waste contamination. This practice may also serve to reduce erosional processes along stream banks due to reduced animal traffic.

Slow Release Fertilizer - The use of slow release fertilizers minimizes nitrogen losses from soils prone to leaching. Slow release fertilizer is used somewhat for strawberries, and citrus crops in the south Florida area.

Soil Testing and Plant Analysis - These practices involve testing of soil and plants to avoid overfertilization and subsequent losses of nutrients in runoff water.

Timing and Placement of Fertilizers - The proper timing and placement of fertilizers provides for maximum utilization by plants and minimum leaching or movement by surface runoff. The practice works well with drip irrigation systems. Citrus growers use split applications to save fertilizer.

Waste Management System - A practice utilizing a planned system in which all necessary components are installed for managing liquid and solid waste, including runoff from concentrated waste areas, such that air, soil, and water resources are not degraded. The purpose of this practice is to manage waste in rural areas such that air, soil, and water resources are not degraded, and to manage waste in order to protect public health and safety. These systems should preclude pollutant discharges to surface or groundwater and should recycle waste through soil and plants to the fullest extent practical. The practice applies where: waste is generated by agricultural production; waste from municipal and industrial treatment plants is used in agricultural production; all practice components necessary to make a complete system are specified; and soil, water, and plant resources are adequate to properly manage waste. These systems may consist of a single component, such as a diversion, or may consist of several components. Examples of components that could be used in a waste management system include fencing, pond sealings or linings, subsurface drains, water storage ponds, waste treatment lagoons, and grassed waterways or outlets.

Waste Utilization - Waste utilization is the practice of using agricultural wastes and other wastes on land in an environmentally acceptable manner while maintaining or improving soil and plant resources. Waste utilization is a means to safely use wastes to provide fertility for crop, forage, or fiber production; to improve or maintain soil structure; to prevent erosion; and to safeguard water resources. The practice involves the use of wastes for application to crops. Recommended waste application rate guidelines are listed in the NRCS Field Office Technical Guide. This practice may also include recycling of waste solids for animal feed supplement.

Water Table Management - Water table management or control is the practice of controlling the water table through proper use of subsurface drains, water control structures, and water conveyance facilities for the efficient removal of drainage water and distribution of irrigation water. The practice improves the soil environment for vegetative growth by regulating the water table to remove excess runoff and subsurface water, facilitate leaching of saline or alkali soil, and regulate or manage groundwater for sub-irrigation. The practice applies where: a high water table exists; topography is relatively smooth and flat; adequate water is available; the benefits of sub-irrigation, in addition to controlling groundwater and surface runoff, justify system installation; soil depth and permeability will permit effective operation of the control system; saline or sodic soil conditions can be maintained for an acceptable level for efficient production of crops; a suitable outlet exists; and improvements for off-site water quality are needed and can be achieved through water table management techniques.

Water Tolerant Crops - This practice involves the careful selection of water tolerant crops for organic soils so higher water tables can be maintained to reduce oxidation and release of nutrients to drainage water.

Water/Feeder Location - This practice involves the locating of feeders and watering facilities a reasonable distance from streams and water courses. The practice serves to reduce livestock concentrations, particularly near streams, and to encourage more uniform grazing. Properly locating watering and feeding facilities can improve surface water quality and reduce erosion around stream and creek banks.

WATER/IRRIGATION BMPs

Irrigation Water Conveyance - An irrigation water conveyance consists of a fixed lining of impervious material installed in an existing or newly constructed irrigation field ditch, irrigation canal, or lateral. Irrigation water conveyances are used to prevent waterlogging of land, to maintain water quality, to prevent erosion, and to reduce water loss. The practice is applicable to ditches and canals that serve as integral parts of an irrigation water distribution or conveyance system that has been designed to facilitate the conservative use of soil and water resources on a farm or group of farms.

Irrigation Water Management - The use of proper irrigation water management involves the determination and control of the rate, amount, and timing of irrigation water application in a planned and efficient manner through use of flow meters and potentiometers. The purpose of irrigation water management is to effectively use available irrigation water supply in managing and controlling the moisture environment of crops to promote the desired crop response and to minimize soils erosion, runoff, and fertilizer and pesticide movement, and to protect water quality. In order for the above stated purpose to be achieved, the manager of a conservation irrigation system must have the capability and knowledge to: determine when irrigation water should be applied based on the rate of water use by the crop and the stages of plant growth; measure or estimate the amount of water required for each irrigation, including the leaching needs; determine the normal time needed for the soil to absorb the required amount of water and how to detect changes in intake rates; adjust stream size, application rate, or irrigation time to compensate for changes in such factors as intake rate or the amount of water to be applied; recognize erosion caused by irrigation; estimate the amount of irrigation runoff from an area; and evaluate the uniformity of water application.

Land Leveling (with Laser) - Land leveling is the practice of reshaping the surface of the land to be irrigated to planned grades. Land leveling permits uniform and efficient application of irrigation water without causing erosion, loss of water quality, or damage to land by waterlogging, yet at the same time provides for adequate surface or subsurface drainage. Soils should be deep enough so that after leveling work is completed an adequate and usable root zone remains that will produce satisfactory crop production with proper conservation measures. In the Tampa Bay Watershed, land leveling is most important for crops utilizing seep irrigation systems.

Mulching - Mulching is the practice of applying plant residues, or other suitable materials not produced on the site, to the soil surface. Mulching conserves moisture, prevents surface compaction or crusting; reduces runoff and wind and water erosion; controls weeds; and helps establish plant cover. Mulching is applicable to soils subject to erosion on which low residue producing crops are grown, on critical areas and on soils that have a low infiltration rate.

Pasture and Hayland Management - Pasture and hayland management involves the proper treatment and use of pastureland and hayland. The practice serves to prolong the life of desirable forage species; to maintain or improve the quality and quantity of forage; and to protect the soil and reduce water loss. Pasture and hayland management practices can be used on all pastureland or hayland. An important aspect of these practices focuses on balancing fertilization according to production needs. Most Florida soils need fertilization to produce optimum yields of forage crops. Fertilization programs must consider the production needs and nutrient requirement of the forage crop, as well as the ability of the soil to retain and deliver nutrients and water. Although the NRCS Field Office Technical Guide provides specifications on fertilization of forage crops without the benefit of soil test results, the NRCS highly recommends the use of annual soil testing to assess fertilization requirements.

Pasture and Hayland Planting - Pasture and hayland planting practices primarily serve to establish forage plants on erodible soils to reduce runoff and erosion.

Prescribed Burning - Prescribed burning is the practice of applying fire to predetermined areas such that the intensity and spread of the fire are controlled. Prescribed burning practices control undesirable vegetation; prepare sites for planting and seedings; control plant diseases; reduce fire hazards; improve wildlife habitat, forage production, and forage quality; and facilitate distribution of grazing and browsing animals.

Range Seeding - Range seeding is the practice of establishing adapted plants by seeding on rangeland. Range seeding prevents excessive soil and water loss; produces more forage on rangeland or land converted to range from other uses; and improves the aesthetic quality of the grazing land. This practice is applicable on rangeland, native pasture, grazable woodland, and grazed wildlife land.

Trickle Irrigation System - A trickle irrigation system (e.g., Spray Jet Irrigation or Drip Irrigation) is a planned system in which necessary facilities are installed for efficiently applying water directly to the root zone of plants via small diameter pipes, and by using special applicators (orifices, emitters, porous tubing, perforated pipe) operated under low pressure. The applicators may be placed on or below the ground surface. These systems maintain soil moisture within the range for good plant growth without excessive water loss, erosion, reduction in water quality, or salt accumulation. The design of a trickle irrigation system is based on an evaluation of the site and the expected operating conditions. The soils and topography must be suitable for irrigation of the proposed crops, and the water supply must be sufficient in quantity and quality for the intended crops to be grown. Trickle irrigation is suited to most orchard (or grove) crops and row crops as well as for gardens, flowers, and shrubs in urban settings where small flow rates of water can be used efficiently. According to the NRCS's Technical Guide for agricultural BMPs, the field application efficiency of trickle irrigation systems may reach 90%.

Water Table Management - Water table management or control is the practice of controlling the water table through proper use of subsurface drains, water control structures, and water conveyance facilities for the efficient removal of drainage water and distribution of irrigation water. The practice improves the soil environment for vegetative growth by regulating the water table to remove excess runoff and subsurface water, facilitate leaching of saline or alkali soil, and regulate or manage groundwater for sub-irrigation. The practice applies where: a high water table exists; topography is relatively smooth and flat; adequate water is available; the benefits of sub-irrigation, in addition to controlling groundwater and surface runoff, justify system installation; soil depth and permeability will permit effective operation of the control system; saline or sodic soil conditions can be maintained for an acceptable level for efficient production of crops; a suitable outlet exists; and improvements for off-site water quality are needed and can be achieved through water table management techniques.

Water Tolerant Crops - This practice involves the careful selection of water tolerant crops for organic soils so higher water tables can be maintained to reduce oxidation and release of nutrients to drainage water.

PESTICIDE USE BMPs

Correct Pesticide Application - Correct pesticide application practices involve the responsible use of pesticides to minimize pesticide movement from the field where application are made. Practices may include the spraying of pesticides when conditions for drift are minimal, and mixing the pesticide properly with soil when specified, and avoiding applications when heavy rain is forecast.

Correct Pesticide Container Disposal - Correct pesticide container disposal practices refer to the use of the accepted methods for pesticide container disposal (such as those specified on the pesticide label).

Cultural Control of Pests - The cultural control of pests refers to using cultural practices, such as elimination of host sites and adjustment of planting schedules (i.e., crop rotation), to partly substitute for pesticides. The use of this practice should reduce the amount of pesticides introduced into the environment and thus protect surface and ground water quality from pesticide contamination.

Integrated Pest Management (IPM) - IPM practices encompass of variety techniques to minimize or preclude the use of pesticides on agricultural crops. Practices include the use of crop rotation to reduce buildup of insects, the use of alternate control methods such as cover crops to foster populations of beneficial insects, the determination of economic pest thresholds, the adjusting of planting and harvest periods, and the use of field scouting. Additional components that may be part of an IPM program include the use of natural enemies and pheremones. These later components are primarily used in ornamental horticulture.

Irrigation Water Management - The use of proper irrigation water management involves the determination and control of the rate, amount, and timing of irrigation water application in a planned and efficient manner through use of flow meters and potentiometers. The purpose of irrigation water management is to effectively use available irrigation water supply in managing and controlling the moisture environment of crops to promote the desired crop response and to minimize soils erosion, runoff, and fertilizer and pesticide movement, and to protect water quality. In order for the above stated purpose to be achieved, the manager of a conservation irrigation system must have the capability and knowledge to: determine when irrigation water should be applied based on the rate of water use by the crop and the stages of plant growth; measure or estimate the amount of water required for each irrigation, including the leaching needs; determine the normal time needed for the soil to absorb the required amount of water and how to detect changes in intake rates; adjust stream size, application rate, or irrigation time to compensate for changes in such factors as intake rate or the amount of water to be applied; recognize erosion caused by irrigation; estimate the amount of irrigation runoff from an area; and evaluate the uniformity of water application.

Pesticide Selection - Proper pesticide selection practices refer to the selection of pesticides which are less toxic, persistent, soluble, and volatile as feasible for worker safety and protection of environment.

EROSION CONTROL BMPs

Conservation Cropping System - Conservation cropping is a system of growing crops in combination with needed cultural and management measures to improve the soil and protect it during periods when erosion occurs. Conservation cropping practices provide vegetative cover (often weed fallow) between crop seasons. The practice may include cover cropping and crop rotation.

Critical Area Planting - Critical area planting is the planting of vegetation such as trees, shrubs, grasses or legumes on critical areas. Critical area planting serves to stabilize the soil, reduce erosion and runoff to downstream areas, improve wildlife habitat, and enhance natural beauty. Applicable areas include sediment-producing, highly erodible or severely eroded areas, such as dams, dikes, ditches, mine spoil, levees, cuts, fills, surface-mined areas, and denuded or gullied areas where vegetation is difficult to establish with usual seeding or planting methods.

The NRCS Field Office Technical Guide includes detailed specifications for five categories of critical area plantings; they include:

342-I) Permanent Seedings;
342-II Temporary Seedings;
342-III Sod;
342IV With Ground Cover, Vines, Shrubs and Other Plants; and
342-V On Coastal Dune Areas.

Deferred Grazing - Deferred grazing practices postpone grazing for a prescribed period to improve vegetative conditions and reduce soil loss. Deferred grazing promotes natural revegetation by improving the health of the forage stand and permitting desirable plants to produce seed. Deferred grazing also serves to provide a feed reserve for fall and winter grazing or emergency use, reduce soil loss and improve water quality, and maintain or improve wildlife habitat. Deferred grazing practices that employ planned deferment periods can be applied to all rangeland, native pasture, grazable woodland, and grazed wildlife land. Planned deferment periods should be based on: the type of plants managed for, timing of "green-up" and active growth period, and plant vigor; the vigor and growth habits of the key forage species; weather and growing conditions; and the land user's goals. The planned deferment, however, must not cause overuse or have an adverse impact on the rest of the operating unit.

Fencing - Fencing is the dividing or enclosing of land areas with a suitable permanent structure the acts as a barrier for livestock, game, or people. Fencing serves to: subdivide grazing land to permit use of planned grazing systems; exclude livestock or big game from plant communities that cannot withstand grazing; confine livestock or big game in an area; regulate access to areas by people and prevent trespassing; distribute grazing pressures more evenly thereby enhancing the quality of runoff water; and allow deferment periods to be incorporated with brush management practices thereby improving the efficiency of water use.

Field Windbreak - A field windbreak is a strip or belt of trees (e.g., cedar trees wind blocks for potato farms) established in or adjacent to a field. Field windbreaks serve to reduce soil erosion from wind; conserve moisture; protect crops, groves, livestock, and wildlife; or increase the natural beauty of an area. Field windbreaks can be grown in or around open fields needing protection against wind damage, or where strips of trees or shrubs increase the natural beauty of an area or provide food and cover for wildlife.

Grassed Waterways or Outlet - This BMP includes natural or constructed channels or outlets that are shaped or graded to required dimensions and established in suitable vegetation for the stable conveyance of runoff. This BMP applies to natural or constructed channels that are to be established with vegetation and used for water disposal. Grassed waterways serve to convey runoff from terraces, diversions, or other water concentrations without causing erosion or flooding and to improve water quality. This practice is applicable to all sites where added capacity, vegetative protection, or both are required to control erosion resulting from concentrated runoff and where such control can be achieved by using this practice alone or combined with other conservation practices. The practice should not be used where its construction would destroy important woody wildlife cover and where the present watercourse is not seriously eroding.

Irrigation Water Conveyance - An irrigation water conveyance consists of a fixed lining of impervious material installed in an existing or newly constructed irrigation field ditch, irrigation canal, or lateral. Irrigation water conveyances are used to prevent waterlogging of land, to maintain water quality, to prevent erosion, and to reduce water loss. The practice is applicable to ditches and canals that serve as integral parts of an irrigation water distribution or conveyance system that has been designed to facilitate the conservative use of soil and water resources on a farm or group of farms.

Irrigation Water Management - The use of proper irrigation water management involves the determination and control of the rate, amount, and timing of irrigation water application in a planned and efficient manner through use of flow meters and potentiometers. The purpose of irrigation water management is to effectively use available irrigation water supply in managing and controlling the moisture environment of crops to promote the desired crop response and to minimize soils erosion, runoff, and fertilizer and pesticide movement, and to protect water quality. In order for the above stated purpose to be achieved, the manager of a conservation irrigation system must have the capability and knowledge to: determine when irrigation water should be applied based onthe rate of water use by the crop and the stages of plant growth; measure or estimate the amount of water required for each irrigation, including the leaching needs; determine the normal time needed for the soil to absorb the required amount of water and how to detect changes in intake rates; adjust stream size, application rate, or irrigation time to compensate for changes in such factors as intake rate or the amount of water to be applied; recognize erosion caused by irrigation; estimate the amount of irrigation runoff from an area; and evaluate the uniformity of water application.

Land Leveling (with Laser) - Land leveling is the practice of reshaping the surface of the land to be irrigated to planned grades. Land leveling permits uniform and efficient application of irrigation water without causing erosion, loss of water quality, or damage to land by waterlogging, yet at the same time provides for adequate surface or subsurface drainage. Soils should be deep enough so that after leveling work is completed an adequate and usable root zone remains that will produce satisfactory crop production with proper conservation measures. In the Tampa Bay Watershed, land leveling is most important for crops utilizing seep irrigation systems.

Mulching - Mulching is the practice of applying plant residues, or other suitable materials not produced on the site, to the soil surface. Mulching conserves moisture, prevents surface compaction or crusting; reduces runoff and wind and water erosion; controls weeds; and helps establish plant cover. Mulching is applicable to soils subject to erosion on which low residue producing crops are grown, on critical areas and on soils that have a low infiltration rate.

Pasture and Hayland Management - Pasture and hayland management involves the proper treatment and use of pastureland and hayland. The practice serves to prolong the life of desirable forage species; to maintain or improve the quality and quantity of forage; and to protect the soil and reduce water loss. Pasture and hayland management practices can be used on all pastureland or hayland. An important aspect of these practices focuses on balancing fertilization according to production needs. Most Florida soils need fertilization to produce optimum yields of forage crops. Fertilization programs must consider the production needs and nutrient requirement of the forage crop, as well as the ability of the soil to retain and deliver nutrients and water. Although the NRCS Field Office Technical Guide provides specifications on fertilization of forage crops without the benefit of soil test results, the NRCS highly recommends the use of annual soil testing to assess fertilization requirements.

Pasture and Hayland Planting - Pasture and hayland planting practices primarily serve to establish forage plants on erodible soils to reduce runoff and erosion.

Prescribed Burning - Prescribed burning is the practice of applying fire to predetermined areas such that the intensity and spread of the fire are controlled. Prescribed burning practices control undesirable vegetation; prepare sites for planting and seedings; control plant diseases; reduce fire hazards; improve wildlife habitat, forage production, and forage quality; and facilitate distribution of grazing and browsing animals.

Proper Grazing Use - Proper grazing use is the practice of grazing at an intensity that will maintain enough vegetative cover to protect the soil and maintain or improve the quantity and quality of desirable vegetation. This practice serves to increase the vigor and reproduction of key plants; accumulate litter and mulch necessary to reduce erosion and sedimentation and improve water quality; improve or maintain the condition of existing vegetation; increase forage production; maintain natural beauty; reduce hazard of wildfire; and improve or maintain wildlife habitat. The practice is applicable on all rangeland, native pasture, and grazed wildlife land.

Range Seeding - Range seeding is the practice of establishing adapted plants by seeding on rangeland. Range seeding prevents excessive soil and water loss; produces more forage on rangeland or land converted to range from other uses; and improves the aesthetic quality of the grazing land. This practice is applicable on rangeland, native pasture, grazable woodland, and grazed wildlife land.

Rotational Grazing - Rotational grazing is a system in which two or more grazing units are alternately rested and grazed in a planned sequence for a period of years. The rest periods may be throughout the year or during the growing season of key plants. Rotational grazing serves several purposes, including: to maintain existing plant cover or hasten its improvement while properly using the forage of all grazing units; to improve water quality and reduce erosion; to increase grazing efficiency by uniformly using all parts of each grazing unit; to provide adequate forage throughout the grazing season; to improve forage quality and increase production; to enhance wildlife habitat; to promote flexibility in the grazing program and buffer the adverse affects of drought; and to promote energy conservation by using reduced amounts of fossil fuel.

Runoff Management System - A system for controlling excess runoff caused by construction operations at development sites, changes in land use, or other land disturbances such as the preparation of a field for a new crop. Proper runoff management serves to regulate the rate and amount of runoff and sediment from development sites during and after construction operations to minimize undesirable effects such as flooding, erosion, and sedimentation. A properly designed runoff management system should be used if there is a need to control runoff, erosion, and sedimentation to compensate for increased peak discharges and erosion resulting from construction activities. The practice involves the planning, design, installation, operation, and maintenance of runoff management systems, including adequate outlet facilities and components necessary for adequate management of storm runoff. Components may include dams, excavated ponds, infiltration trenches, parking lot storage, rooftop storage, and underground tanks.

Shade Areas - Shade areas serve to lessen the need for animals to enter water for relief from heat by using trees or artificial shelters to provide shade at selected locations. Such practices minimize animal contact with surface waters and thereby serve to protect surface waters from animal waste contamination. This practice may also serve to reduce erosional processes along stream banks due to reduced animal traffic.

Water/Feeder Location - This practice involves the locating of feeders and watering facilities a reasonable distance from streams and water courses. The practice serves to reduce livestock concentrations, particularly near streams, and to encourage more uniform grazing. Properly locating watering and feeding facilities can improve surface water quality and reduce erosion around stream and creek banks.

Woodland Site Management - Woodland site management is the practice of managing soils and vegetation in woodland areas to encourage rapid growth of desirable trees in order to reduce soil erosion runoff.

Table 6-3. Agricultural BMPs applicable in the Estero Bay Watershed including the problems addressed by agricultural land use type.

PROBLEM ÷	**NITROGEN LOADING**			**WATER USE/ IRRIGATION**			**PESTICIDE USE**			**EROSION**		
LAND USE TYPE ÷ RC= Row Crop CG=Citrus Grove P/L=Pasture/Livestock	RC	CG	P/L	RC	CG	P/L	RC	CG	P/L	RC	CG	P/L
BMP												
Conservation Cropping System										X		
Correct Pesticide Application							X	X				
Correct Pesticide Container Disposal							X	X				
Critical Area Planting										X	X	X
Cultural Control of Pests							X	X		X		
Deferred Grazing												X
Fencing			X									X
Field Windbreak										X		
Grassed Waterways or Outlet			X									X
Integrated Pest Management							X	X	X			
Irrigation Water Conveyances				X	X					X	X	
Irrigation Water Management	X	X		X	X		X	X		X	X	
Land Absorption/Wetland Use			X									
Land Leveling (with Laser)				X								
Mulching	X			X						X		
Nutrient Management	X	X	X									
Pasture & Hayland Management			X			X			X			X

Table 6-3. Agricultural BMPs applicable in the Estero Bay Watershed including the problems addressed by agricultural land use type.

PROBLEM ÷	**NITROGEN LOADING**			**WATER USE/ IRRIGATION**			**PESTICIDE USE**			**EROSION**		
LAND USE TYPE ÷ RC= Row Crop CG=Citrus Grove P/L=Pasture/Livestock	RC	CG	P/L	RC	CG	P/L	RC	CG	P/L	RC	CG	P/L
Pasture and Hayland Planting			X			X			X			X
Pesticide Selection							X	X				
Prescribed Burning						X						X
Proper Grazing Use												X
Range Seeding						X						X
Resistant Crop Varieties							X	X				
Rotational Grazing			X									X
Runoff Management System	X	X	X	X	X	X	X			X	X	X
Shade Areas			X									X
Slow Release Fertilizer	X	X	X									
Soil Testing & Plant Analysis	X	X	X									
Timing & Placement of Fertilizers	X	X	X									
Trickle Irrigation System				X	X							
Waste Management System			X									
Waste Utilization			X									
Water Table Management				X	X							
Water Tolerant Crops				X	X	X						
Water/Feeder Location			X									X

6.5.2 Urban BMPs

Urban BMPs can be categorized as structural and non-structural BMPs. Non-structural practices are generally those that do not require the construction of facilities (e.g. public education on controlling fertilizer use, garbage disposal, and street sweeping). Structural practices broadly include facilities for infiltration, filtration, and detention.

STRUCTURAL BMPs

Infiltration Basins - Infiltration basins are impoundments in which incoming urban runoff is temporarily stored until it gradually infiltrates into the soil surrounding the basin. Infiltration basins should drain within 72 hours to maintain aerobic conditions, which favor bacteria that aid in pollutant removal, and to ensure that the basin is ready to receive the next storm (Schueler, 1987). The runoff entering the basin is pretreated to remove coarse sediment that may clog the surface soil pore on the basin floor. Concentrated runoff should flow through a sediment trap, or a vegetated filter strip may be used for sheet flow.

Infiltration Trenches - Infiltration trenches are shallow excavated ditches that have been backfilled with stone to form an underground reservoir. Urban runoff diverted into the trench gradually infiltrates from the bottom of the trench into the subsoil and eventually into the ground water. Variations in the design of infiltration trenches include dry wells, pits designed to control volumes of runoff (such as the runoff from a rooftop), and enhanced infiltration trenches, which are equipped with extensive pretreatment systems to remove sediment and oil. Depending on the quality of the runoff, pretreatment will generally be necessary to lower the failure rate of the trench. More costly than pond systems in terms of cost per unit of runoff treated, infiltration trenches are suited best for drainage areas of less than 5 to 10 acres or where ponds cannot be utilized (Schueler et al., 1992).

Vegetated Filter Strips - Vegetated filter strips are areas of land with vegetative cover that are designed to accept runoff as overland sheet flow from upstream development. They may closely resemble many natural ecotones, such as grassy meadows or riparian forests. Dense vegetative cover facilitates sediment attenuation and pollutant removal. Vegetated filter strips do not effectively treat high-velocity flows and are therefore generally recommended for use in agricultural and low-density development and other situations where runoff does not tend to be concentrated. Unlike grassed swales, vegetated filter strips are effective only for overland sheet flow and provide little treatment for concentrated flows. Grading and level spreaders can be used to create a uniformly sloping area that distributes the runoff evenly across the filter strip (Dillaha et al., 1987). Vegetated filter strips are often used as pretreatment for other structural practices, such as infiltration basins and infiltration trenches.

Filter strips are less effective on slopes of over 15%. Periodic inspection, repair, and regrading are required to prevent channelization (Schueler et al., 1992). Inspection is especially important following major storm events. Excessive use of pesticides, fertilizers, and other chemicals should be avoided. To minimize soil compaction, vehicular traffic and excessive pedestrian traffic should be avoided.

A berm of sediment that must be periodically removed may form at the upper edge of grassed filter strips. Mowing of grassed filter strips at a minimum of two to three times per year will maintain a thicker vegetative cover, providing better sediment retention. To avoid impacts on ground-nesting birds, mowing should be limited to spring or fall (USEPA, undated). Harvesting of mowed vegetation will allow for thicker growth and promotes the retention of nutrients that are released during decomposition (Dillaha et al., 1989).

Forested areas directly adjacent to waterbodies should be left undisturbed except for the removal of trees presenting unusual hazards and the removal of small debris near the stream that may be refloated by high water. Periodic harvesting of some trees not directly adjacent to waterbodies removes sequestered nutrients (Lowrance, Leonard, and Sheridan, 1985) and maintains an efficient filter through vigorous vegetation (USEPA, undated). Exposure of forested filter strip soil to direct radiation should be avoided to keep the temperature of water entering waterbodies low, and moist conditions conducive to microbial activities in filter strips should be maintained (Natter and Gaskin, 1989).

Grassed Swales (Vegetated) - A grassed swale is an infiltration/filtration method that is usually used to provide pretreatment before runoff is discharged to treatment systems. Grassed swales are typically shallow vegetated man-made ditches designed so that the bottom elevation is above the water table to allow runoff to infiltrate into ground water. The vegetation or turf prevents erosion, filters sediment, and provides some nutrient uptake (USDA-S.S., 1988).

The swale should be mowed at least twice yearly to stimulate vegetative growth, control weeds, and maintain the capacity of the system. It should never be mowed shorter than 3 to 4 inches. The established width should be maintained to ensure the continued effectiveness and capacity of the system (Beastlier, undated). Grassed swales are applicable to the project area and are quite frequently used in new developments.

Porous Pavement and Permeable Surfaces - Porous pavement, an alternative to conventional pavement, reduces much of the need for urban runoff drainage conveyance and treatment off-site. Instead, runoff is diverted through a porous asphalt layer into an underground stone reservoir. The stored runoff gradually exfiltrates out of the stone reservoir into the subsoil. Many states no longer promote the use of porous pavement because it tends to clog with fine sediments (Washington Department of Ecology, 1992). A vacuum-type street sweeper should be used to maintain porous pavement.

Permeable paving surfaces such as modular pavers, grassed parking areas, and permeable pavements may also be employed to reduce runoff volumes and trap vehicle-generated pollutants (Pitt, 1990; Smith, 1981); however, care should be taken when selecting such alternatives. The potential for ground-water contamination, compaction, or clogging due to sedimentation should be evaluated during the selection process. (NOTE: These practices should be selected only in cases where proper operation and maintenance can be guaranteed due to high failure rates without proper upkeep).

Concrete Grid Pavement - Concrete grid pavement consists of concrete blocks with regularly interspersed void areas that are filled with pervious materials, such as gravel, sand, or grass. The blocks are typically placed on a sand or gravel base and designed to provide a load-bearing surface that is adequate to support vehicles, while allowing infiltration of surface water into the underlying soil.

Water Quality Inlets - Water quality inlets are underground retention systems designed to remove settleable solids. Several designs of water quality inlets exist. In their simplest form, catch basins are single-chambered urban runoff inlets in which the bottom has been lowered to provide 2 to 4 feet of additional space between the outlet pipe and the structure bottom for collection of sediment. Some water quality inlets include a second chamber with a sand filter to provide additional removal of finer suspended solids by filtration. The first chamber provides effective removal of coarse particles and helps prevent premature clogging of the filter media. Other water quality inlets include an oil/grit separator. Typical oil/grit separators consist of three chambers. The first chamber removes coarse material and debris; the second chamber provides separation of oil, grease, and gasoline; and the third chamber provides safety relief should blockage occur (NVPDC, 1980). While water quality inlets have the potential to perform effectively, they are not recommended. Maintenance and disposal of trapped residuals and hydrocarbons must occur regularly for these devices to work. No acceptable clean-out and disposal techniques currently exist (Schueler et al., 1992).

Extended Detention Ponds - Extended detention (ED) ponds temporarily detain a portion of urban runoff for up to 24 hours after a storm, using a fixed orifice to regulate outflow at a specified rate, allowing solids and associated pollutants the required time to settle out. The ED ponds are normally "dry" between storm events and do not have any permanent standing water. These basins are typically composed of two stages: an upper stage, which remains dry except for larger storms, and a lower stage, which is designed for typical storms. Enhanced ponds are equipped with plunge pools near the inlet, a micropool at the outlet, and an adjustable reverse-sloped pipe as the ED control device (orifice) (NVPDC, 1980; Schueler et al., 1992). Temporary and most permanent ED ponds use a riser with an antivortex trash rack on top to control trash.

Wet Ponds - Wet ponds are basins designed to maintain a permanent pool of water and temporarily store urban runoff until it is released at a controlled rate. Enhanced designs include a forebay to trap incoming sediment where it can easily be removed. A fringe wetland can also be established around the perimeter of the pond.

Constructed Wetlands - Constructed wetlands are engineered systems designed to simulate the water quality improvement functions of natural wetlands to treat and contain surface water runoff pollutants and decrease loadings to surface waters. Where site-specific conditions allow, constructed wetlands or sediment retention basins should be located to have a minimal impact on the surrounding areas. In addition, constructed urban runoff wetlands differ from artificial wetlands created to comply with mitigation requirements in that they do not replicate all of the ecological functions of natural wetlands. Enhanced designs may include a forebay, complex microtopography, and pondscaping with multiple species of wetland trees, shrubs, and plants.

Filtration Basins and Sand Filters - Filtration basins are impoundments lined with filter media, such as sand or gravel. Urban runoff drains through the filter media and perforated pipes into the subsoil. Detention time is typically 4 to 6 hours. Sediment-trapping structures are typically used to prevent premature clogging of the filter media (NVPDC, 1980; Schueler et al., 1992).

Sand filters are a self-contained bed of sand to which the first flush of runoff water is diverted. The runoff percolates through the sand, where colloidal and particulate materials are strained out by the cake of solids that forms, or is placed, on the surface of the media. Water leaving the filter is collected in underground pipes and returned to the stream channel. A layer of peat, limestone, and/or topsoil may be added to improve removal efficiency.